LBNE Beam Design Simulations

3/24/10

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Requirements of the FNAL/Homestake Beam

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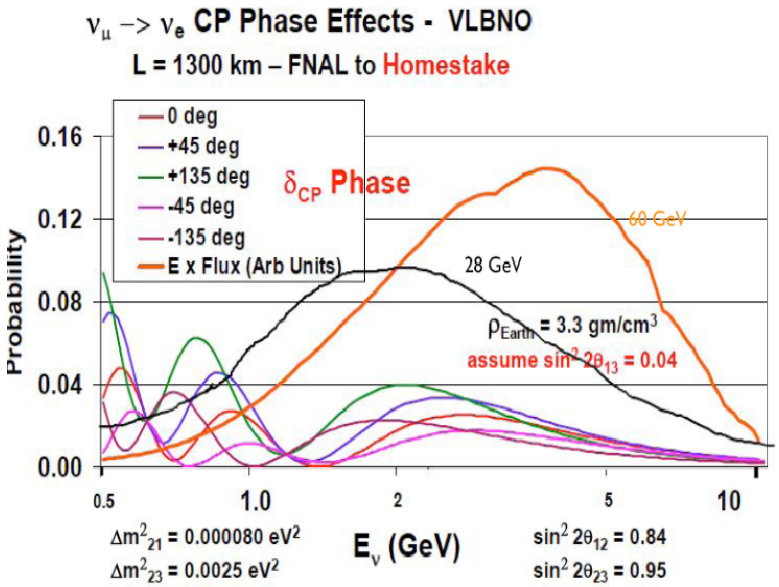
The design specifications of a new WBLE beam based at the Fermilab MI are driven by the physics of $\nu_\mu \longrightarrow \nu_e$ oscillations:



L = 1300 km

Requirements:

-Maximal possible neutrino fluxes to encompass the 1st and 2nd oscillation nodes, with maxima at 2.4 and 0.8 GeV.

-High purity ν_μ beam with negligible ν_e

-Minimize the neutral-current feed-down contamination at lower energy, therefore minimizing the flux of neutrinos with energies greater than 6 GeV is highly desirable.

Summary of LBNE Beam Design Efforts

- **Since 2008 a NuMI based design using the 2 NuMI horns, a shortened target chase and cylindrical graphite target fully embedded in Horn 1 has been the default reference design. The DP is evacuated with a radius of 2m and a length of 280-380m. This design was used to estimate physics sensitivities in 2009.**
- **In Fall 2009, Byron Lundberg conducted a detailed study of a 2-horn and 3-horn focusing design and concluded that 2 parabolic horns with an embedded target are sufficient (for a conventional horn focused beam).**
- **In early 2010, a new parabolic 2-horn conceptual design with an embedded water cooled target has been proposed. Alysia has implemented the beamline design in GNUMI and Mary has implemented the new target design in FLUKA08.**
- **In this talk, I will summarize the performance of the new design and compare to the 2008 NuMI-like reference design.**

Proton Target Designs

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Parameter	2008	2010
Material	Carbon-Composite	Graphite
Density	2.1 g/cm^3	1.8 g/cm^3
Target shape	Cylindrical	Cylindrical
Radius	0.6 cm	0.75cm
Length	80 cm	96.6cm
Cooling material	He	Water
Cooling element	None	SS cylinder ID 0.02cm OD 0.03cm

The beam is 120 GeV
p^+, $\sigma_x = \sigma_y = 0.15$cm, dy/dz = dx/dz = 0.01mrad.

Focusing Horn Designs

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Horn 1

Parameter	2008	2010
Conductor	Al	Al
Shape	Double parabolic	Cylindrical/Parabolic
Inner Al thickness:	2mm min	4.5mm cylindrical portion
	4.5mm (max at neck)	3mm parabolic
Outer conductor	30.66 cm ID	56 cm ID
	32.40 cm OD	60 cm OD
Front Al thickness	3mm	4mm
End Al thickness	3mm	4mm
Minimum aperture field-free neck:	0.9cm radius	1.2 cm radius
Length:	3.0 m	3.2m
Current:	250-350 kA	300 kA

Focusing Horn Designs

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Horn 2

Parameter	2008	2010
Shape:	Double parabolic	Same
Conductor:	Al	Same
Inner conductor thickness:	3mm min	Same
	5mm max	Same
Outer conductor :	74.00 cm ID	Same
	75.74 cm OD	Same
Front conductor thickness	3mm	
End conductor thickness	3mm	
Minimum aperture		
field-free neck:	3.9cm radius	Same
Length:	3.0m	Same
Current:	250-350 kA	300 kA
Distance from H1 upstream end	6m	6.6m

Comparison of LBNE 2 horn Beamline Designs

LBNE Beam Design Simulations

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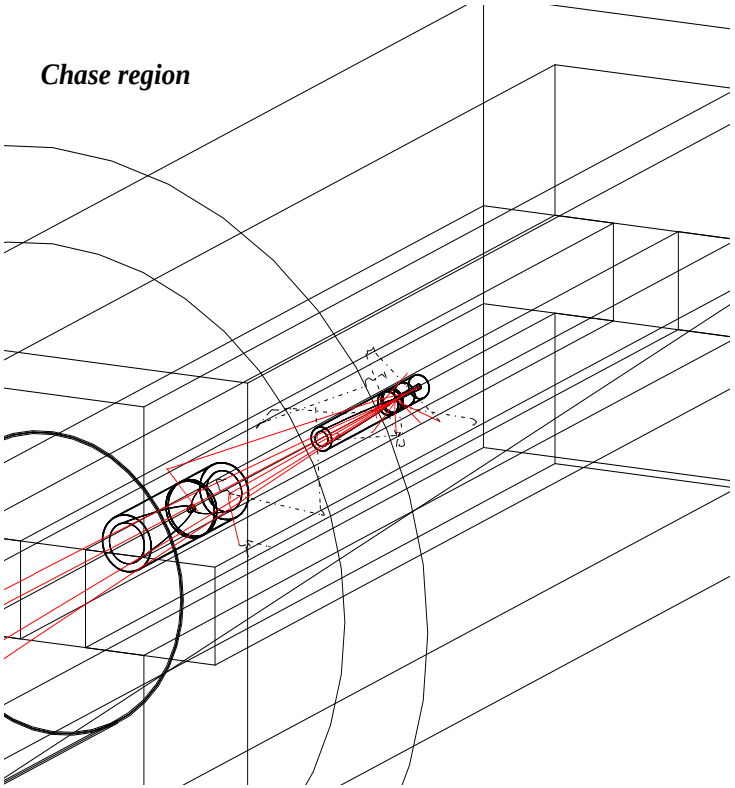
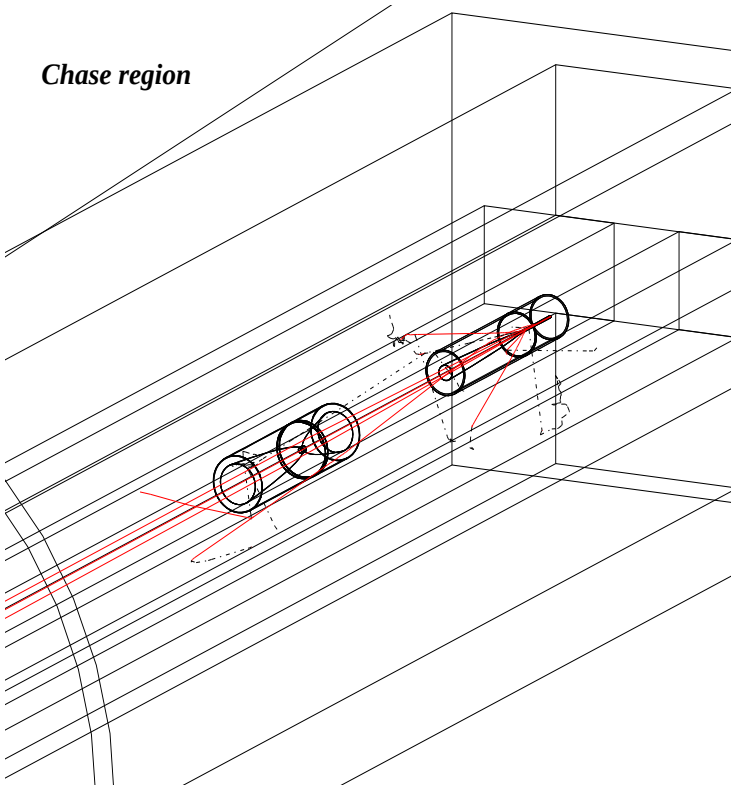
NuMI-like 2-horns



LBNE 2-horns (Byron)



Target chase = 6x6x19.28 m, Horn 1 8m downstream **Target chase = 6x6x28 m, Horn 1 is 3m downstream**

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LBNE Beam Design Simulations

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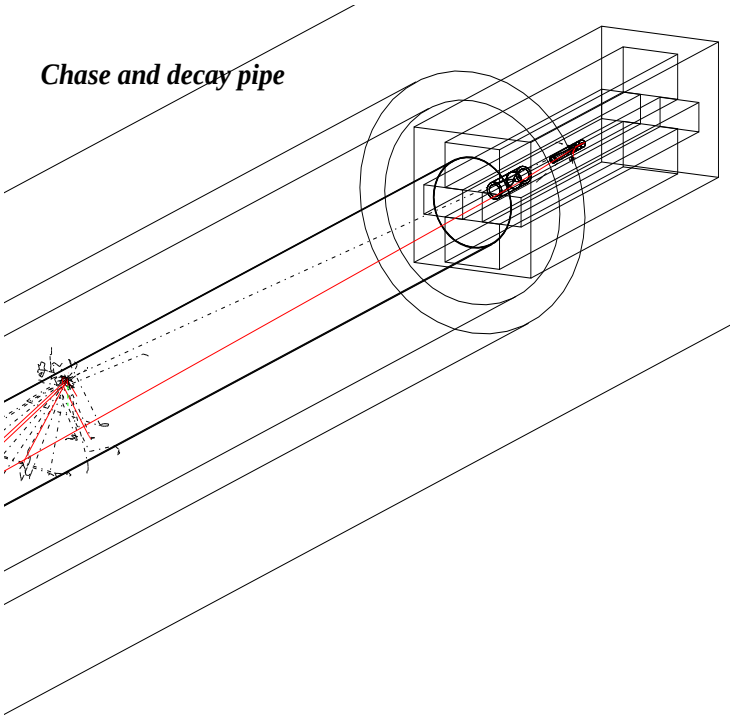
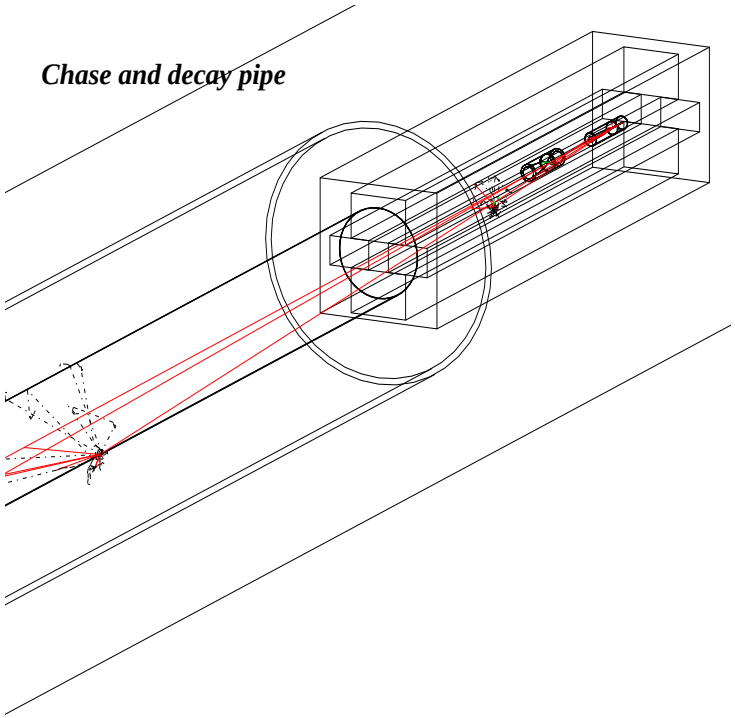
NuMI-like 2-horns



LBNE 2-horns (Byron)



Decay pipe r=2m, L=280m, shielding thick= 2.5m, vacuum Decay pipe r=2m, L=250m, shielding thick =3.5m, air

Comparison of LBNE 2 horn Beamline Designs

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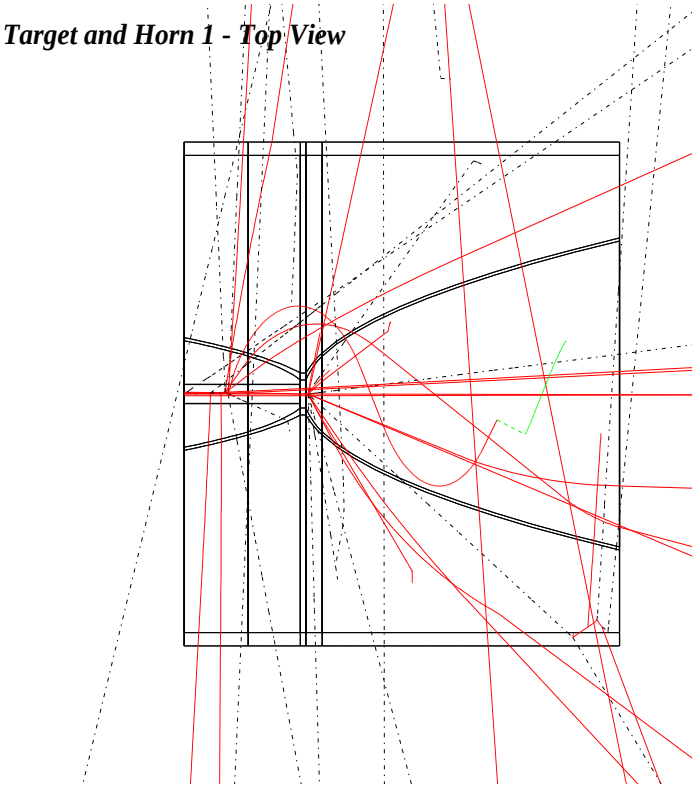
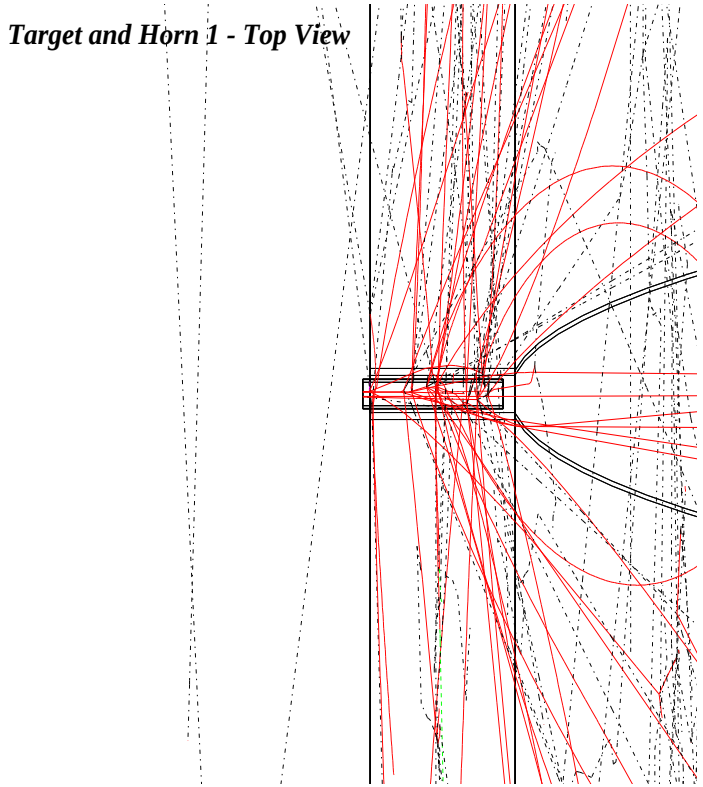
NuMI-like 2-horns



LBNE 2-horns (Byron)



Comparison of LBNE 2 horn Beamline Designs

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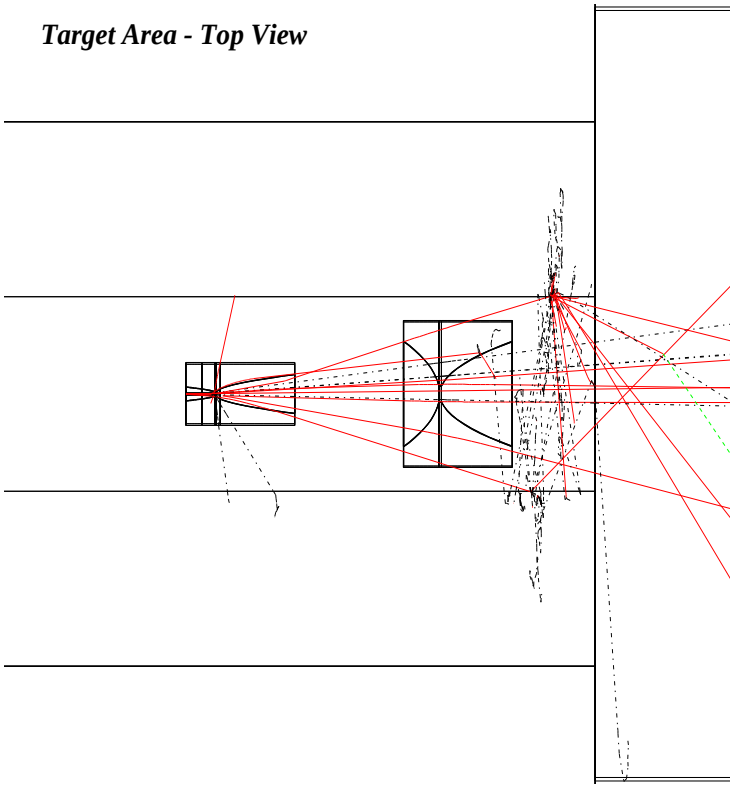
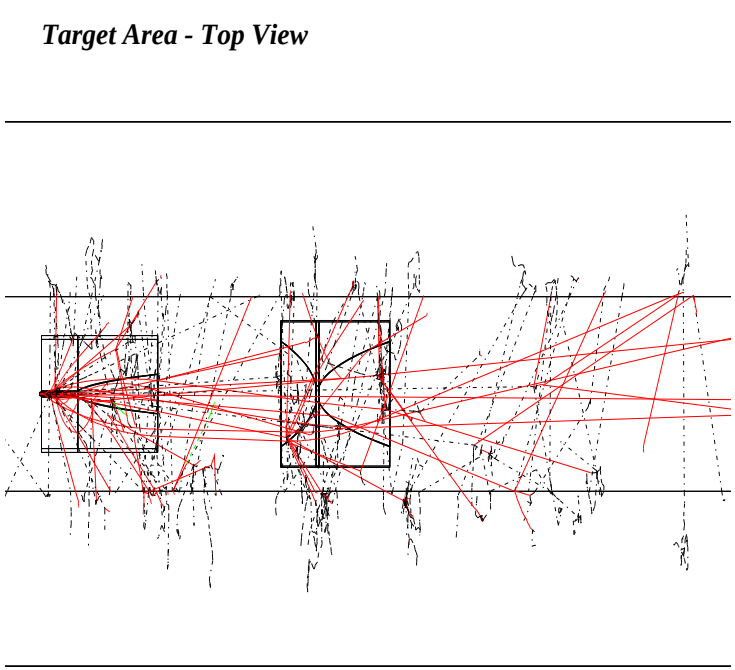
NuMI-like 2-horns



LBNE 2-horns (Byron)



Comparison of NuMI-like/LBNE 2-horn designs

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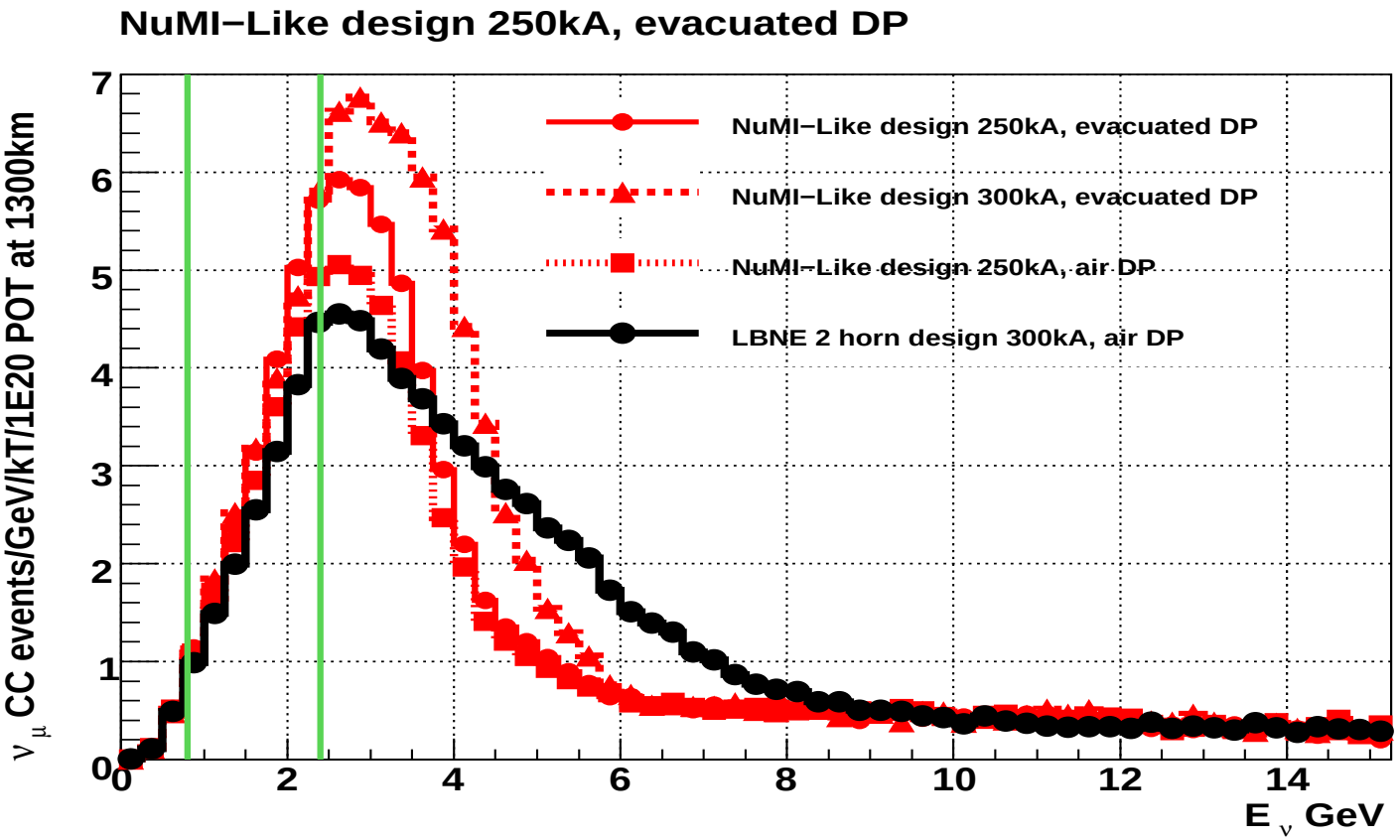

Simulation	0.8 GeV Rate	Peak Rate (E)	6 GeV Rate
	CC events/GeV/kT/MW.yr at 1300km		
NuMI-like, 250kA, vacuum DP	12	60 (2.5 GeV)	7
NuMI-like, 250kA, air DP	10	50 (2.5 GeV)	7
NuMI-like, 300kA, vacuum DP	12	68 (3.0 GeV)	7
LBNE 2-horn, 300kA, air DP	10	45 (2.5 GeV)	17

Summary/Conclusions

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- **The current 2-horn focusing system design being considered for is not as efficient as just using NuMI horns.**
- **We need to iterate further on the 2-horn design.**
- **We do not yet have a study to determine the desirable layout of the target chase and deployment of the shielding that meets the physics specifications of the experiment.**